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Review

Bauhinia variegata Linn. (Mountain Ebony): a review on ethnobotany, phytochemistry and pharmacology

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SUMMARY

Bauhinia variegata Linn (Mountain Ebony) is a medium-sized, deciduous tree, found throughout India, ascending to an altitude of 1,300 m in the Himalayas. The plant is widely used by the tribals throughout India and popular in various indigenous systems of medicine like Ayurveda, Unani and Homoeopathy. Following the various traditional claims on utility of this plant in curing number of diseases, considerable efforts have been made by researchers to verify its utility through pharmacological screenings. The notable biological activities reported are anthelmintic, antiulcer, antitumour, antimicrobial, anti-inflammatory, antigoitrogenic, hepatoprotective and haemagglutination. Industrially, the plant is widely used for the manufacture of wood wool board, production of tannin, oil, gum and fibre. The plant is also utilized for afforestation to conserve the nature. In this article, a comprehensive account of the cultivation, microscopy, phytochemical investigation, traditional and biologically evaluated medicinal uses of *B variegata* is presented.

Key words: *Bauhinia variegate*; Cultivation; Traditional uses; Phytoconstituents; Pharmacological activities

INTRODUCTION

The *genus Bauhinia* Linn. (Caesalpiniaceae) consists of shrubs or trees, very rarely climbers, distributed throughout the tropical regions of the world. About 15 species of this genus occur in India (Kirtikar and Basu, 1999). Bauhinias are chiefly propagated from seeds; vegetative propagation except inarching has not shown much success. Many industrially useful products such as tannins, fibre, gum and oil are obtained from Bauhinia species. The plants bear fragrant and beautiful flowers and most of the species are grown for ornamental purposes. Bauhinias are also cultivated for afforestation and the manufacture of wood wool board (Puntambekar, 1957). Among these, B tomentosa Linn, B racemosa Lam, B retusa Roxb, B purpurea Linn, B variegata Linn and B malabarica Roxb. Found wide application in traditional systems of medicine (Daniel, 2006).

Bauhinia variegata Linn (BV) is a medium-sized, deciduous tree, found throughout India, ascending to an altitude of 1,300 m in the Himalayas. It is commonly known as Kanchnar in Sanskrit and

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Table 1. Vernacular names of Bauhinia variegata Linn

Languages	Vernacular Names
Sanskrit	Kovidara
English	Mountain ebony, Buddhist bauhinia
Hindi	Kachnar, Kaniar
Marathi	Raktakanchan
Gujarati	Kovindara
Punjabi	Kanchan
Kannada	Kempumandara
Telgu	Devakanchanum
Tamil	Sigappu mandaraii
Urdu	Kachnal
Oria	Kosonaro
Kashmiri	Kanchana
Bengali	Raktakanchana
Assami	Shonapushpaka
Malayam	Kovidaram, Suvarnnamandaram

Mountain Ebony in English (Wealth of India, 1988). In Sanskrit the word Kanchnar means "A glowing beautiful lady". In India, the plant is known by various vernacular names (Table 1). A freshly collected bark of the plant is greyish brown externally and cream colored internally. The internal surface, however, gradually turns red and on drying becomes brown and smooth. The external surface remains greyish brown and rough due to large number of exfoliations, transverse cracks and fissures. On drying, the bark becomes curved and channeled. The fracture is short outside and fibrous within. Leaves are 10 - 15 cm long, rigidly sub-coriaceous and deeply cordate. The flowers are bisexual, irregular and light magenta in color. The pods are long, hard, flat, dehiscent and 10 - 15 seeded (Vaidyaratnam, 1994).

The various parts of the plant viz., flower buds, flowers, stem, stem bark, leaves, seeds and roots are utilized in various indigenous systems of medicine and are popular among the various ethnic groups in India for curing a variety of ailments. Following a large number of claims on the wide range of folk curative properties of BV considerable efforts have been made by the researchers to justify its efficacy as a curative agent through pharmacological investigations. The present review highlights the traditional uses, microscopic, phytochemical and pharmacological investigations carried out on the plant, to explain the multifaceted role of this medicinal plant.

Cultivation aspects

Natural propagation of BV takes place through the seeds. The seeds are dispersed on dehiscence of the pods on the trees and germinate readily when provided with favourable conditions, whereas artificial propagation is carried out by direct sowing of seeds and through stump planting. Both these methods have been found to be equally good and better than planting out one season old entire plants. Branch cuttings normally root with difficulty, but these root well in August, November and February with the application of auxins. Direct sowing is done in lines, spaced about 3 m apart. Germination starts in about a week after the onset of monsoon rains ensuring good soaking of soil. The entire plants have to be transplanted with the ball of earth. Stumps or container grown plants can be preferred for transplanting to raise entire plants. For planting out in July-August, previous year's seeds are sowed in March-April (Chauhan, 1999; Kirsten, 2003).

Phamacognostical studies

Microscopic studies of flowers revealed uni to multicellular covering trichomes. They are broader at the base and pointed at the apex. Thin walled multicellular balloon-shaped gland surmounts the trichomes. Pollen grains are spheroidal and tricolporate pores being broad. Exine is thick, differentiated into sexine and nexine. Ovary is superior with marginal placentation (Dey and Das, 1988). Transverse section of the bark shows 12 - 20 layers of cork cells. The cork is followed by a single layer of phellogen, beneath which lies a wide zone of phelloderm of tangentially elongated to isodiametric cells. Lignified fibres and stone cells are distributed in this region. The pericyclic fibres are broad,

thickly lignified, and have narrow lumen. They are taper at both ends. The phloem is represented by sieve tubes, companion cells, phloem parenchyma, phloem fibres, crystal fibres and stone cells, transversed by uni to biseriate medullary rays (Prakash *et al*., 1978).

Folk medicine

The aborigines of Ghatigaon forests, Gwalior, Madhya Pradesh use the flower buds of BV for the treatment of diarrhoea, dysentery and haemorrhoids (Bhatnagar *et al*., 1973). The flowers are used in piles, oedema and dysentery (Malhotra and Moorthy, 1973), as laxative and anthelmintic (Badhe and Pandey, 1990).

The bark of the plant is medicinally more important and is used by tribals against a variety of ailments. The bark is used in fever, as tonic and astringent (Kapoor and Kapoor, 1980), as antileprotic, in skin diseases and wound healing (Sahu, 1981), antigoitrogenic (Thakur *et al.,* 1992), and as antitumour (Singh and Aswal., 1992). In an ethnobotanical survey of the Eastern Ghat region of Andhra Pradesh the stem bark is documented to be useful for the treatment of asthma (Reddy *et al.,* 2006). The bark is also documented as astringent to the bowels, tonic to the liver and beneficial for the cure of dysmenorrhoea, menorrhagia, tuberculosis, asthma and wounds (Kirtikar and Basu, 1999). The leaves are used in the treatment of skin diseases and stomatitis (Balajirao *et al.,* 1995). The roots are used as an antidote for snake poisoning, in dyspepsia, flatulence and as carminative (Bhatnagar *et al.,* 1973; Kapoor and Kapoor, 1980). They are also reported to be useful as antitumour and in obesity (Shah and Joshi, 1971).

Ayurveda

In Ayurvedic literature the plant is known by various names as Kanchnar, Gandari, Yugmapatra and Karbudara. It is reported to have Kasaya rasa, Ruksha guna, Shita virya and Katu vipaka. The stem bark of BV is used in the treatment of krimiroga (worm infestation), gandamala (scrofula), apaci (cervical lymphadenitis) and vrana (wounds) (Ayurvedic Pharmacopoeia, 1990; Kapoor, 2005).

Ayurvedic practitioners have been using the bark powder of BV in combination with other drugs for the treatment of various ailments. In combination with myrrh (Commiphora molmol Engler), turmeric (Curcuma domestica Linn.) and ashoka (Saraca indica Linn.), it is used in gynaecological conditions. For the treatment of lymphatic swelling it is given with guggulu (Commiphora wightii Linn.), punarnava (Boerhaavia diffusa Linn.) and triphala (equal parts of Terminalia belerica Linn., Terminalia chebula Retz. and Emblica officinalis Gaerth). In osteoporosis, BV is prescribed with ashwagandha (Withania somnifera (Linn.) Dunal), bakuchi (Mimusops elengi Linn.), ginger (Zingiber officinale Roscoe.) and guggulu. Diarrhoea is treated in combination with kutki (Picrorrhiza kurroa Linn.) and bibhitaki (Terminalia belerica Linn.) (Sebastian, 2006). Kanchnar guggul, an Ayurvedic formulation [ingredients: kanchnar bark (10 parts) ginger, black pepper, long pepper, cardamom, cinnamon, tejpatra leaves (Cassia cinnamon), triphala (1 part of each of the above herbs)] is commercially available for the treatment of TB tumors, ulcers, gonorrhoea, increase white blood cells (Uniyal *et al.,* 1998).

Unani

In Unani system of medicine, bark of the plant is described as astringent to the bowels and tonic to the liver. It is reported to be useful in treatment of leucoderma, leprosy, menorrhagia, asthma, wounds and ulcers. The flower buds are claimed to be useful in piles, cough, eye diseases, liver complaints and as styptic in haematuria and menorrhagia (Nadkarni, 1954; Chopra *et al.,* 1956).

Root bark and root

Phytochemical analysis of the root bark of BV yielded a new flavanone, (2S)-5, 7-dimethoxy-3, 4-methylenedioxyflavanone and a new dihydrodibenzoxepin, 5,6-dihydro-1,7-dihydroxy-3,4-dimethoxy-

2-methyldibenzoxepin. The structures of the new compounds were determined on the basis of spectral studies (Moporu *et al.,* 2003). A novel flavonol glycoside 5,7,3',4'-tetrahydroxy-3-methoxy-7-O-alpha-L-rhamnopyranosyl(1--)3)-O-beta-galactopyranoside isolated from the roots of BV and its structure was identified by spectral analysis and chemical degradations (Yadava and Reddy, 2003).

Stem bark and stem

The stem bark showed presence of hentriacontane, octacosanol, stigmasterol (Prakash and Khosa, 1976) and of sterols, glycosides, reducing sugars and nitrogenous substances on preliminary phytochemical screening (Prakash and Khosa, 1978). The stem yielded a flavonone glycoside characterized as 5, 7-dihydroxyflavonone-4–O–α-L–rhanmopyranosyl-β–D–glucopyranoside (Gupta *et al.,* 1979). The isolation of β-sitosterol, lupeol, kaempferol-3-glucoside and a 5, 7-dimethoxyflavonone-4–O–α–L–rhamnopyranosyl-β-D-glucopyranoside was also reported from the stem of the plant (Duret and Paris, 1977, Gupta *et al.,* 1980). A flavonol glycoside, characterized as kaempferol-3-glucoside, was isolated from stem of this plant (Gupta and Chauhan, 1984).

A new phenanthraquinone, named bauhinione, has also been isolated from B. variegata, and its structure has been elucidated as 2, 7-dimethoxy-3-methyl-9,10-dihydrophenanthrene-1,4-dione on the basis of spectroscopic analysis (Zhao *et al.,* 2005).

Leaves

Two new long chain compounds, heptatriacontan-12, 13-diol and dotetracont-15-en-9-ol have been isolated from the leaves of BV. Structures of these compounds have been elucidated by spectral data analyses and chemical studies (Singh *et al.,* 2006).

The leaves were also found to contain crude protein, calcium and phosphorous. Due to its nutritive value, the leaves were recommended as fodder for cattle (Sharma *et al.,* 1968).

Leaves of BV were also reported to contain volatile oil. The analysis of oil by GC/MS showed presence of germacrene D, spathulenol, δ- and γ-cadinene (Joaquim *et al.,* 2004).

Buds

Keto acids of flowering buds were analyzed during their development and correlated with the free amino acids and amides. Only four amino acids appeared in early stages. α-Alanine, aspartic acid, glycine and glutamic acid were present in all samples. Glutamic acid showed a sharp drop from initial to later stages. Phosphoenolpyruvic acid, oxaloacetic acid and α-ketoglutaric acid appeared in later stages. Their absence in early stages attributed to their rapid utilization in floral bud development (Mukherjee and Laloraya, 1977).

Pharmacological studies

BV has been screened scientifically for various pharmacological activities. It has significant activities such as anthelmintic, antiulcer, antitumour, antimicrobial, anti-inflammatory, antigoitrogenic, hepatoprotective and haemagglutination. The reported pharmacological activities of various parts of the plant are summarized in Table 2.

Anthelmintic activity

Following the traditional claim, a study was conducted to investigate the anthelmintic potential of the stem bark of BV. The crude ethanolic extract of the plant was evaluated for anthelmintic activity using Indian earthworm Pheretima posthuma L.Vaill (Annelida) and Ascardia galli Schrank (Nematode) as test worms. Various concentrations (10 - 100 mg/ml) of ethanolic extract were tested in the bioassay, which involved determination of time of paralysis (P) and time of death (D) of the worms. Piperazine citrate (10 mg/ml) was included as reference standard. The results of the study showed promising anthelmintic activity at higher concentration of 100 mg/ml when compared with the standard included in the study (Mali *et al.,* 2008).

Table 2. Pharmacological activities of B. variegata Linn.

Activity	Part of the plant/Extract used	Reference
Anthelmintic	Stem bark/Ethanol	Mali et al., 2008
Antiarthritic	Stem/Ethanol	Rajkapoor et al., 2007
Antigoitrogenic	Stem/Alcohol	Veena et al., 1975
Anti-inflammatory	Roots/Isolated flavonol glycoside	Yadava and Reddy, 2003
Antimicrobial	Stem/Juice	Bhavsar et al., 1965
	Leaves/Methanol	Sharma and Saxena, 1996
	Stem/Aqueous, methanol	Parekh et al., 2006
	Leaves, stem/hot water	Chiang et al., 2003
Antitumour	Stem/Ethanol	Rajkapoor et al., 2003a
		Rajkapoor et al., 2003b
		Rajkapoor et al., 2006
Antiulcer	Stem/Alcohol	Rajkapoor et al., 2003
Haemagglutination	Seed/Saline extract	Roy and Bhalla, 1981
Hepatoprotective	Stem bark/Alcohol	Bodakhe and Alpana, 2007
Insecticidal	Stem/Ethanol	Srivastava et al., 1985

Antiarthritic activity

In one study, effect of ethanol extract of stem of BV was evaluated for antiarthritic activity on Complete Freund's Adjuvant (CFA) induced arthritis in rats. The extract was administered orally at the dose level of 250 mg/kg for 15 days. The paw volume was measured at day 3, 5, 10 and 15. At the end of 15 days, the animals were sacrificed and various biochemical parameters such as serum aspartate transaminase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), total cholesterol and triglycerides were estimated. Antioxidant enzymes such as superoxide dismutase (SOD), catalase, glutathione peroxidase (GPx) and lipid peroxide (LPO) in liver and kidney of normal, arthritic control and extract treated rats were studied. The results demonstrated that oral administration of extract of BV significantly ($P < 0.01$) inhibited rat paw edema volume and altered the biochemical parameters which got affected in arthritic rats. Also significant alteration in LPO, SOD, catalase and GPX levels were observed when compared to arthritic control rats (Rajkapoor *et al.,* 2007).

Antigoitrogenic activity

The plant is useful remedy for the treatment of goitre in folk medicine. To validate the claim, effect of alcoholic extract of stem of BV was studied on neomercazole induced goitre model in Swiss albino rats. In the results of study, plant was found significantly effective in bringing the goitrogenic thyroid to normal level at a dose of 200 mg/day (Veena *et al.,* 1975).

Anti-inflammatory activity

A study was conducted on isolated novel flavonol glycoside, 5,7,3',4'-tetrahydroxy-3-methoxy-7-O-alpha-L-rhamnopyranosyl(1--3)-O-beta-d-galactopyranoside, from the roots to evaluate the anti-inflammatory potential of it. The results of the investigation showed significant anti-inflammatory activity of the flavonol glycoside in all the parameters studied (Yadava and Reddy, 2003).

Antimicrobial activity

In one study, the fresh juice of the plant was screened for antimicrobial study and found devoid of bacteriostatic activity against Staphylococcus aureus and Escherichia coli (Bhavsar *et al.,* 1965). In another study, the methanolic extract of leaves exhibited antibacterial activity against Proteus vulgaris, Bacillus anthracis, Escherichia coli, Streptococcus agalactiae and antifungal activity against Aspergillus fumigatus and A. niger (Sharma

and Saxena, 1996). The leaf extract also exhibited toxicity against ringworms caused by fungi Epidermophyton floccosum, Trichophyton mentagrophytes and Microsporum gypseum (Mishra *et al.,* 1991).

The aqueous and methanolic extract of BV were evaluated against five bacterial strains, viz., Bacillus cereus, Staphylococcus aureus, Klebsiella pneumoniae, Escherichia coli and Pseudomonas pseudoalcaligenes. The most susceptible bacteria were found to be K. pneumoniae, B. cereus and the most resistant bacteria were E. coli. (Parekh *et al.,* 2006a). In another study, BV bark powder was defatted with petroleum ether. The non-defatted as well as defatted plant material was then individually extracted in different solvents with increasing polarity, viz., 1,4-dioxan, acetone, methanol, dimethyformamide (DMF) and distilled water respectively. The antibacterial activity of all extracts (non-defatted and defatted) was determined by agar well diffusion method at the three different concentrations of 10 mg/ml, 5 mg/ml and 2.5 mg/ml. The antibacterial activity of defatted extracts was found more than non-defatted extracts against the test microorganisms (Parekh *et al.,* 2006b).

In one study, the hot water extracts of 8 traditionally used medicinal plants in Taiwan including BV were investigated in vitro for their activities against adenoviruses (ADV) and herpes simplex viruses (HSV). The extracts from seed and fruit of Adenanthera pavonina, seeds of Arachis hypogaea and Pisum sativum, stem and leaf of Bauhinia purpurea and B. variegata, and whole plant of Desmodium caudatum, D. triflorum and Glycine max were used. The human skin basal cell carcinoma cell line (BCC-1/KMC) was used as target cells for virus infection. All the extracts exhibited antiviral activity with different degrees of potency. Only 2 extracts viz. B. variegata and D. caudatum were found active in suppressing both HSV and ADV infections. Three extracts (Adenanthera pavonia, D triflorum and P sativum) inhibited only ADV infection, whereas one extract (Arachis hypogaea) blocked only HSV infection (Chiang *et al.,* 2003).

Antitumor activity

The antitumor potential of the ethanol extract stem of B. variegata (EBV) has been evaluated against Dalton's ascitic lymphoma (DAL) in Swiss albino mice. A significant enhancement of mean survival time of EBV-treated tumor bearing mice was found with respect to control group. EBV treatment was found to enhance peritoneal cell counts. After 14 days of inoculation, EBV is able to reverse the changes in the haemotological parameters, protein and PCV consequent to tumor inoculation (Rajkapoor *et al.,* 2003a).

The antitumor activity of ethanol extract of BV was evaluated against Ehrlich ascites carcinoma in Swiss albino mice and found to be a potent cytotoxic towards Ehrlich ascites carcinoma tumour cells (Rajkapoor *et al.,* 2003b).

In another study, the chemopreventive and cytotoxic effect of ethanol extract of B. variegata (EBV) was evaluated in N-nitrosodiethylamine (DEN, 200 mg/kg) induced experimental liver tumor in rats and human cancer cell lines. Oral administration of ethanol extract (250 mg/kg) effectively suppressed liver tumor induced by DEN as revealed by decrease in DEN induced elevated levels of serum glutamate pyruvate transaminase (SGPT), serum glutamate oxaloacetate transaminase (SGOT), alkaline phosphatase (ALP), total bilirubin, gamma glutamate transpeptidase (GGTP), lipid peroxidase (LPO), glutathione peroxidase (GPx) and glutathione S-transferase (GST).

The extract produced an increase in enzymatic antioxidant (superoxide dismutase and catalase) levels and total proteins when compared to those in liver tumor bearing rats. The histopathological changes of liver samples were compared with respective controls. EBV was found to be cytotoxic against human epithelial larynx cancer (HEp2) and human breast cancer (HBL - 100) cells. These results showed a significant chemopreventive and cytotoxic

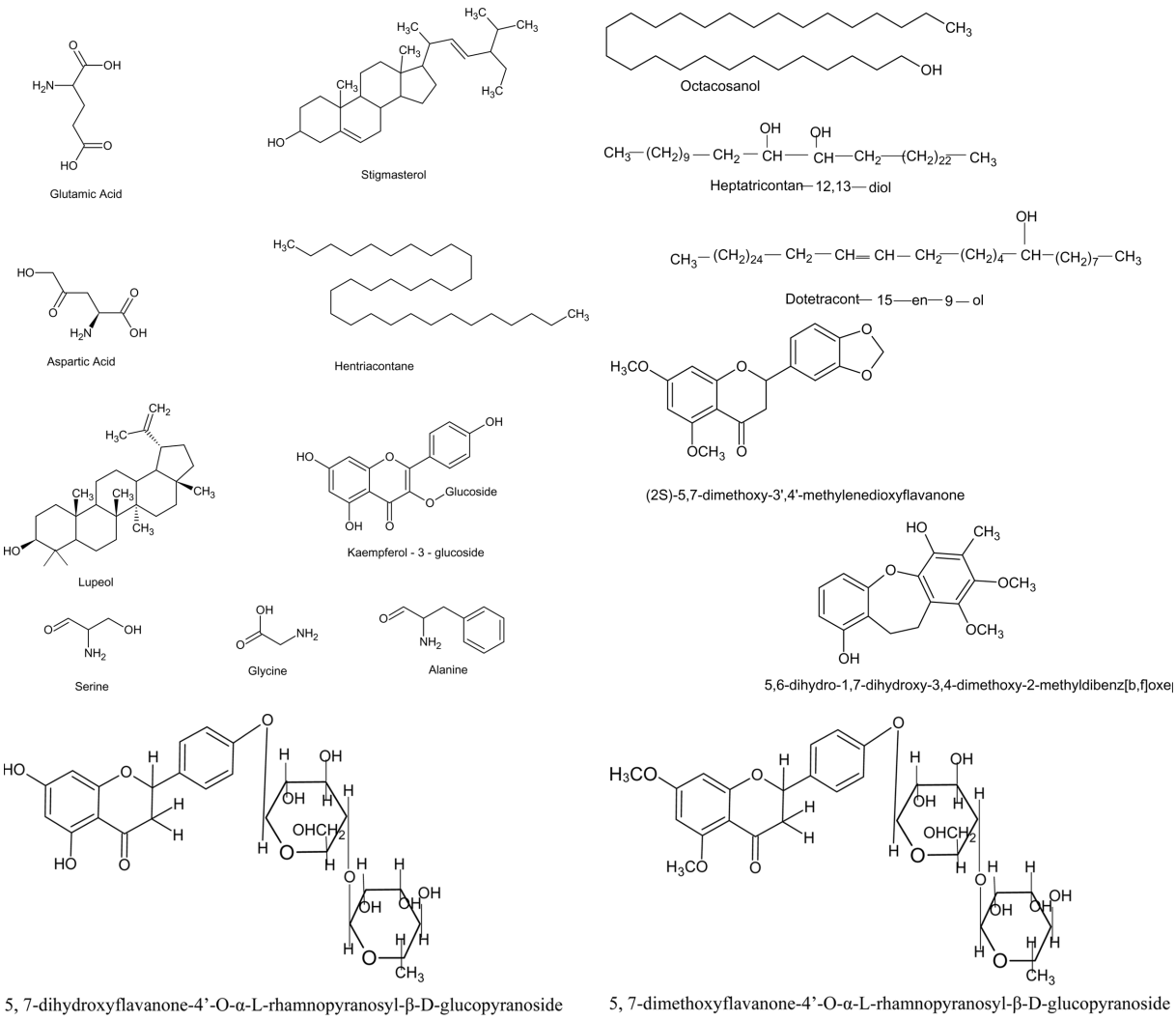

Fig. 1. Isolated phytoprinciples from *Bauhinia variegata Linn*.

effect of EBV against DEN induced liver tumor and human cancer cell lines (Rajkapoor *et al.,* 2006).

Anti-ulcer activity

The plant is good remedy for the treatment of mouth ulcer in traditional systems of medicine. To validate the claim in scientific manner, ulcer protective effect of alcoholic extract of stem of BV was tested against gastric ulcer induced by pyloric ligation and aspirin induced ulcer model in Swiss albino rats. The stomach was incised along with greater curvature and examined for ulcer. The volume of gastric secretion, total free acidity and ulcer index were determined. Oral administration of alcoholic extract of BV exhibited significant ($P < 0.001$) decrease in the volume of gastric secretion, total, free acidity and ulcer index with respect to control group of rats (Rajkapoor *et al*., 2003).

Haemagglutination activity

The saline extract of seed exhibited haemagglutination activity against erythrocytes of man, monkey, rabbit, rat, goat, sheep, cow, buffalo, horse, mule and fowl (Roy and Bhalla, 1981).

Hepatoprotective activity

To validate the traditional claim for the cure of jaundice, the hepatoprotective activity of stem bark of BV was investigated in carbon tetrachloride (CCL4) intoxicated Sprague-Dawley rats. The alcoholic stem bark extract of the plant at different doses (100 and 200 mg/kg) was administered orally to male rats. The effects of extract on serum enzymes, viz., AST, ALP, ALT, GGT and liver proteins and lipids were assessed. The significant hepatoprotective activity of the extract was found at 200 mg/kg against CCL4 induced liver damage (Bodakhe and Alpana, 2007).

Insecticidal activity

In one study, the ethanol extract of stem of the plant showed juvenilizing activity against Dysdercus cingulatus nymphs (Srivastava *et al.,* 1985).

Miscellaneous study

A comparative study was conducted on the asexual propagation of BV by shoot cuttings and propagation by seeds. Cuttings were obtained from the apex, centre and base of active shoots of mature trees, during autumn (November) and summer (July) 1998 and 1999. Cuttings were dipped in solutions of 2,000 – 6,000 ppm IBA and planted under mist in a peat-perlite (1 : 1 v/v) substrate. After 4 months, the rooting of summer cuttings was 20% or lower, whereas that of autumn cuttings was as high as 60%. Rooting was most successful when cuttings were taken from the basal region of shoots and treated with 2000 ppm IBA. Seeds were collected from the same trees 5 months after flowering, placed in Petri dishes, and incubated at 10 - 35°C. Germination was highest at 25 - 30°C (84 - 85%), and the rate of germination was fastest at the same temperatures (T50 = 5.5 - 6.0 days). Germinated seeds were transferred to plastic pots and plant survival was 100% after 5 months. Although published data on other Bauhinia species indicate poor seed germination and a low survival rate for cuttings, the results of study showed that BV can be satisfactorily propagated by cuttings taken from the basal region of shoots in autumn, but the success rate was found lower than for seeds (Akoumianaki-Ioannidou *et al.,* 2004).

CONCLUSION

In the present article, we have reviewed the relevant literature to congregate the botanical, pharmacognostical, ethnobotanical, phytochemical and pharmacological information on Bauhinia variegata. A survey of literature revealed that the plant is having promising anthelmintic, antiarthritic, antigoitrogenic, anti-inflammatory antitumour, cytotoxic, antimicrobial, antiulcer, haemagglutination, hepatoprotective and insecticidal activity. A critical analysis of the literature also pin points the fact that although the number of diseases for which BV finds use as a medicine is fairly large, yet its therapeutic efficacy has been assessed only in a few cases. In view of the wide range of medicinal uses of BV as mentioned in ethnobotanical surveys, Ayurveda, Unani system and otherwise, it is imperative that more clinical and pharmacological studies at molecular level, should be conducted to investigate unexploited potential of this plant. In conclusion, further studies on B. variegata should be designed for standardization of various extracts for the purpose of their use in specific herbal formulations, investigation of the molecular mechanisms of action of isolated phytoprinciples using biological and clinical screenings and subsequent development of lead from them.

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